Design of Rapid Sand Filters by Capping of Coconut Shell

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Abstract: A study was carried out to determine about the rapid sand filter which are very commonly used in Conventional water treatment plants. The rapid sand filter beds are suffering by the problems like Mud ball formation, unsatisfactory effluent, etc. Dual media and multimedia filters can overcome the limitations of RSF. Capping of crushed coconut shell is used as a Dual Media. Designing Dual media filter capped with crushed coconut shell proves to be more efficient, economical and durable. The sample was collected from nearby lake which was highly turbid and having high amount of total solids. A fabricated model was prepared having dimensions 0.5 x 0.5 x 0.9m. Gravel, Sand, Coconut Shell was filled in the model in the layer of size 20cm, 15cm, and 20cm respectively. The tests which are conducted on the sample are pH, Turbidity, BOD and Total solids. It improves the performance of filter in the terms of high filtration rate, high turbidity removal and high decrease in percentage of total solids and thus making it more applicable. This filter media reduces about 90% of turbidity. The amount of total solids was decreased about 89%.

KEYWORDS: Rapid Sand Filter, Coconut Shell, Filtration, Turbidity, pH, BOD, Total Solids.

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I. INTRODUCTION

Filtration is a process that is widely used for removing fine particles from water. Almost all conventional Surface water treatment facilities and some Ground water treatment facilities make use of Rapid Sand Filter. Rapid sand filter is commonly used in the treatment of surface water supplies. Some form of pretreatment of raw water, such as sedimentation, is usually needed. Most of the conventional water treatment plants are overloaded due to increase in demand which highlights the need of higher filtration rate. Dual media and multimedia filters can overcome these limitation of RSF alternatively higher filtration rates even can be achieved. However, the use of such techniques is limited to India due to unavailability of filter materials apart from sand.

Capping is the process of covering the filtration media by appropriate caps such as anthracite coal, bituminous coal, crushed coconut shell, etc. Capping involves the replacement of portion of sand with appropriate caps. The proposed study was made to assess the use of Coconut shell as capping media. Coconut shells are easily available and it helps to tackle some additional flock loads. It improves the quality of filtration with respect to bacterial measure.

1.1 NECESSITY

Capping is the process of covering the filter media by appropriate caps such as anthracite coal, bituminous coal, crushed coconut shell, etc. Capping involves the replacement of portion of sand with appropriate caps. The proposed study was made to assess the use of Coconut shell as capping media. Coconut shells are easily available and it helps to tackle some additional flock loads. It improves the quality of filtration with respect to bacterial measure.

1.2 OBJECTIVES

1. To suggest more efficient filter design.
2. To remove the turbidity effectively.
3. To increase filtration rate and runtime.
4. To reduce backwashing requirement.
5. To check the efficiency of capping media.
6. To provide economical method for purification of water.
7. To make use of largely easily and naturally available material for capping.
8. To check the quality of water and its pollution extent on basis of parameters such as pH, turbidity, hardness, etc.

II. RELATED WORK

Mota Manoj H et.al.(2012) studied the effect of capping of RSF by the use of coconut shell as a capping media by pilot scale study. This study has shown that rapid sand filters are very common in all conventional water treatment plants. Major problem associated with it is stratification; it restricts the complete use of sand bed. Almost all rapid sand filter beds are suffering by problems like high backwash water requirement, unsatisfactory Effluent and mud ball formation. A pilot scale model of filter is constructed using glass columns with an inside area of 0.15 x 0.15m along with piping and valves. The co-efficient of uniformity of sand used was 1.7 and effective size was 0.6mm. The co-efficient of uniformity of capping media used was less than 1.3 and effective size of 1.91mm. Capping is the process of covering filter media by the caps of crushed coconut shell, bituminous coal, anthrax filter, etc. Higher rate of filtration is possible along with less backwash requirements and higher filter run. Backwash requirement for capped RSF caps is less as compared to conventional RSF by 33%. Crushed coconut shell as capping media can increase the filter run by 80%.

Ranjeet Sabale et.al. (2017) studied two pilot filter columns, One is conventional RSF and other is capped RSF. Conventional filter has sand as filter media; capped RSF has PVC granules as a filter media. Conventional rapid sand filter and capped rapid sand filter are compared. Sand media having characteristics as effective size (E.S.- 0.35 to 0.60mm),uniformity co-efficient (U.C. -1.3 TO 1.7), specific gravity -2.67, limiting head loss -1.8to 3m, depth of sand -60cm, depth of gravel support -40cm, etc. Rapid sand has many advantages like easy operation, more filtration rate, easy backwashing, and output. Due to improper backwashing, major problems shown in the filter media is mud-ball formation. Stratification of sand media takes place at the time of backwashing process. Sand grains having small size come at top layer which reduces the porosity. Filtration process is affected due to the increase in head loss in shorter run time. Capping of rapid sand filter is suggested by the researchers to overcome to these problems. Capping is the process in which upper sand bed layer is replaced with few centimeters of capping material. Capping proves efficient techniques for improving the performance of RSF. Capping with PVC granules with 3cm depth gives turbidity removal up to 92%.

Ansari Mubeshshera Awais et.al.(2017) The attempt is made to study the effect of capping of the pilot SF by the use of coconut as capping media by pilot scale study. The pilot scale study has shown very encouraging results. Comparative study shown that higher rate of filtration is possible along with higher filter run and less backwash requirement. Top most layer of 75cm and intermediate layer of 10cm and bottom layer of 10cm. capping with coconut shell proves to be very effective in improving the performance of RSF in pilot scale. Use of filter with coconut shell as capping media for longer period will give better efficiency. Backwash requirement for capped RSF is less as compared to conventional RSF by 33%. Higher rate of filtration can be obtained after capping without much effect on the filtrate quality. Capping of RSF using the crushed coconut shell as capping media can increase the filter run by about 80%.

III. MATERIALS USED

In this chapter, the various materials used in this experiment are:

3.1 Materials:

3.1.1 Gravel:

Gravel which retained on 4.75mm has been used as supporting media for sand layer. The depth of gravel layer in the filtration units is 20cm. Gravel was washed and oven dried thoroughly before using as the supporting filter media layer.

3.1.2 Sand:

River sand having uniformity co-efficient 1.7 and effective size 0.60mm is used as filter material. Sand is washed with clean, sun dried and oven dried before using as a filter media. The depth of sand layer maintained in the filtration unit is 15cm.

3.1.3 Crushed Coconut Shell:

Crushed coconut shells having an effective size of 1.91mm were used as capping media above the sand layer. Crushed coconut shells were placed in layers above the sand as capping. The depth of coconut layer in filtration unit was 20cm. Coconut shells were crushed into pieces manually using a rammer and then thoroughly cleaned before using it as capping. Crushed coconut shells were washed and oven dried for 24 hours.

3.2 Preparation of Model:

Project work was carried out in Environmental Engineering lab, Godavari Institute of Engineering and Technology. Glass fiber sheet of thickness 3mm was cut as per the design. A pilot scale of size 0.5 * 0.5 * 0.9m is fabricated using fiber sheet. An outlet is provided at the bottom for the collection of filtered water. A tap is attached to the outlet opening for controlling the filtration rate. Necessary care has been taken to make the model water tight.

3.3 Study Area:

The sample was collected from the Pittaloola Cheruvu, Rajanagaram. The sample collected was turbid. The sample was collected in cans. The water was transported from the lake to the environmental engineering laboratory and necessary tests were conducted. Water sample was bought to laboratory and it was kept in large containers for sedimentation process with detention period for 3-4 hours. The supernatant water was collected and then passed through Rapid sand filter.

IV. METHODOLOGY

The following procedure was adopted for conducting the experiment:

1. Filter layer consisting of gravel bed of 20cm thickness, sand layer of 15cm thickness and crushed coconut shell layer of 20cm thickness was spread in the filter unit.
2. The water obtained from the lake is stored in a large container for a detention period of about 3-4 hours. The supernatant water after the sedimentation process was passed through the rapid sand filter.

3. Influent water is fed into the filter with the help of a dispenser of 20 liters capacity has been placed well above the filter unit.
4. A head of water above the filter media in the filtration unit of 10cm was maintained throughout the test period. The raw water was fed to filtration unit continuously through the dispenser placed above the filtration unit.
5. Effluent sample were taken at a frequency of every 1 hour. This sample is tested for turbidity, pH, total solids, BOD.
6. The experiment has been carried out up to 8 hours.
7. The following procedures were adopted to test the water sample in the laboratory.

Fig 3.1 Experimental Setup in Laboratory

4.1 Tests conducted on Water sample:

1. **pH Test:**

- In general, water with pH < 7 is considered acidic and with a pH > 7 is considered basic.
- The normal range for pH in surface water systems is 6.5 to 8.5 and for ground water systems is 6 to 8.5.
- Alkalinity is a measure of the capacity of the water to resist the change in pH that would tend to make the water more acidic.

Procedure:

- _Take standard buffer solution of pH=4 into a beaker and insert pH electrode into it very carefully as the electrode is very sensitive and expensive. If the instrument reads a value to exact 4, the instrument is now calibrated and ready for use.
- Take out the electrode, wash it with distilled water and then dip in the sample to be analyzed. Now, read pH value of the sample.

2. **Turbidity Test:**

- It is caused due to presence of suspended and colloidal matter in the water.
- The character and amount of turbidity depends on the type of water sample.
- Generally, there are two types of turbidimeters:

a. Based on visual method (through naked eye)
b. Based on direct (Meter reading)

Procedure:

- Switch on the Nephlometric turbidimeter and wait for few minutes till it warms up.
- Set the instrument at 100 on scale with 40 NTU standard suspension. In this case, every division on the scale will be equal to 0.4 NTU turbidity.
- Shake thoroughly the sample and keep it for some time to eliminate the air bubbles.
- Take the sample in nephlometric sample tube and put the sample chamber and find out value on the scale.
- Dilute the sample with turbidity free water and again read the turbidity.

3. **Total Solids Test :**

- Total solids is a measure of the suspended and dissolved solids in water.
- The total solids in a water sample can be directly determined by evaporating the water and weighing it.

- Total solids are generally determined as the residue left after the evaporation at 103*C to 105*C and subsequently drying of unfiltered sample.

Procedure:

- A clean porcelain dish is ignited in a muffle furnace and after partial cooling in air; it is cooled in a desiccator and weighed (W1).
- A known volume (V1) of about 100 ml of well mixed sample is placed in a dish and evaporated at 103*C for 1 hour.
- Dry to a constant weight at 103*C, cool in desiccator and weigh it (W2).
- Total solids determination is used to access the suitability of potential supply of water for various uses.
- Even the stabilization of pH also depends on the amount of total solids present in water sample.

V. RESULTS AND DISCUSSIONS

- The initial tests conducted on water sample collected has obtained as following values:

Physical Characteristics	Unit	Values Obtained
pH	-	7.85
Turbidity	NTU	24
Total Solids	Mg/L	1900

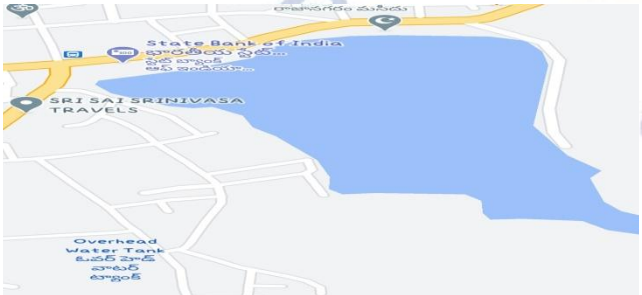

Fig 5.1 Index Map

During the filtration process, Influent and effluent water sample was tested for various parameters like turbidity, pH, total solids and BOD. Every 1 hour during the filtration process the effluent samples were collected and tested.

Table – 2: Turbidity values from hour to hour

Sl. No	Time in Hr	Turbidity Values
1	1	09 NTU
2	2	09 NTU
3	3	08 NTU
4	4	08 NTU
5	5	06 NTU
6	6	06 NTU
7	7	04 NTU
8	8	02 NTU

Table – 3: Total Solids values from Hour to Hour

Sl. No	Time in Hr	Total Solids Values
1	1	430 mg/l
2	2	380 mg/l
3	3	340 mg/l
4	4	300 mg/l
5	5	270 mg/l
6	6	230 mg/l
7	7	190 mg/l
8	8	170 mg/l

Table – 4: pH values from Hour to Hour

Sl. No	Time in Hr	pH Values
1	1	7.71
2	2	7.68
3	3	7.64
4	4	7.60
5	5	7.57
6	6	7.53
7	7	7.38
8	8	7.30

Table – 5: Influent and Effluent BOD

Sl. No	Characteristics	BOD Values
1	Influent BOD	7.8 mg/l
2	Effluent BOD	1.7 mg/l

5.1 Graphical Representations:

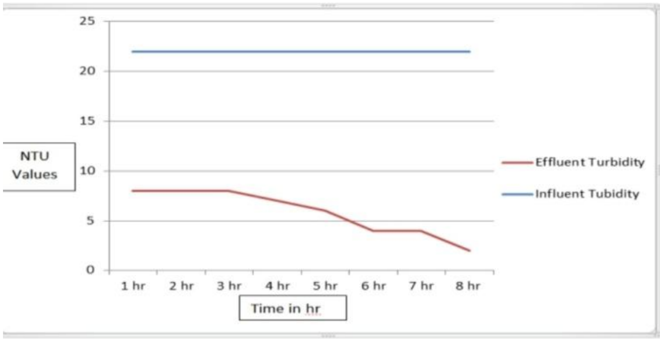

Fig 5.1.1 Graph representing Influent and Effluent Turbidity

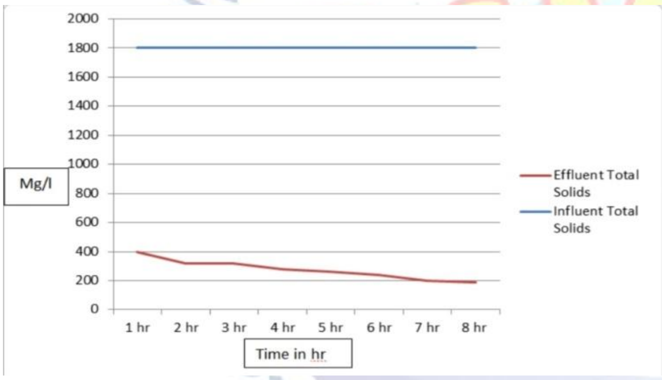

Fig 5.1.2 Graph representing Influent and Effluent Total Solids

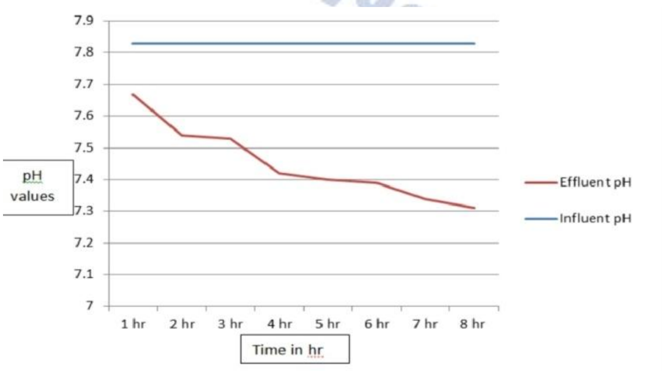

Fig 5.1.3 Graph representing Influent and Effluent pH

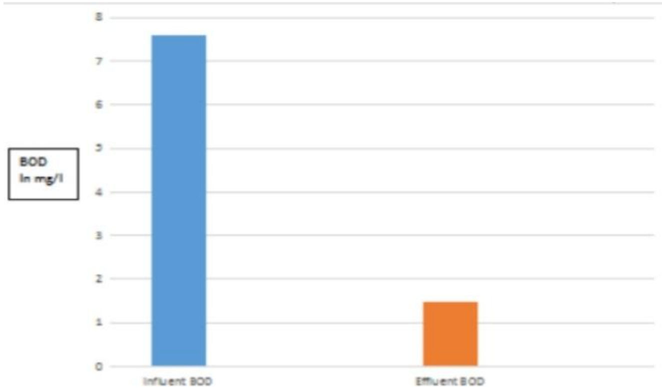

Fig 5.1.4 Graph representing Influent and Effluent BOD

VI. CONCLUSION

As per the experiment is conducted and various tests were performed, the following conclusions were made:

- There is a considerable reduction in the amount of total solids present in sample i.e. up to 89%.
- The turbidity amount is also reduced in the sample nearly up to 90%.
- By using the coconut shell as a capping material for filter media, it had given very good efficiency during the filtration process.
- The coconut shell usage also helped in removing the considerable BOD in water sample efficiently.
- Even, there was a considerable reduction in the color intensity.
- The pH was also changed during this filtration process.

6.1 Performance of Coconut Shell:

i. Generally in the normal rapid sand filters, the gravel base of 45 to 50cm depth with gravel size varying from 3 to50mm in 4 or 5 layers is provided.

ii. In addition to the above layers, by capping the extra layer with crushed coconut shells helps in improving the performance of rapid sand filters.

iii. In the conventional RSF (Rapid Sand Filters), backwashing requirement is slightly high.

iv. Whereas, in the capped RSF, the requirement of backwashing is very less compared to conventional RSF up to 33%.

v. The conventional RSF will have the filter run efficiency generally from 65-75%.

vi. By the capping of filter media, it increases the efficiency of the filter run up to 80% when compared to conventional RSF.
vii. By capping the filter media with PVC granules with 3cm depth gives the turbidity removal up to 92% when compared to the conventional RSF where the efficiency of turbidity removal is 80% approximately.
viii. Even, by this capping of filter media with crushed coconut shell, the filtration rate will be high which results in better quality of water occurred at effluent.
ix. The amount of total solids, color intensity of influent water, the pH value, the amount of BOD, etc. are considerably reduced by capping of filter media with coconut shell when compared to conventional RSF.

- Even, by this capping process, the initial and maintenance costs can be considerably reduced when compared to the conventional RSF where the maintenance cost is somewhat higher.

VII. FUTURE SCOPE

- Capping with coconut shell proves very effective in improving the performance of rapid sand filter in pilot scale.
- This material should be tested for full scale plant to access its suitability for mass scale filtration.
- Use of filter with coconut shell as capping media for longer period will give better performance analysis.
- The intense study on the total life of such capping media as compared to the normal life sand media used conventionally has also to be done.
- Dual media filter proves to be better alternative for filtration units in treatment plant.
- Use of coconut shells as double media other than sand in filter adds qualitative features to conventional rapid sand filters.
- The effective depth of 5-6 cm of capping layer of shells having particle size of 4 mm gives efficient filter design.
- It facilitates main purpose of turbidity removal up to 96%, twice filtration rate, reduced head loss, removal of operational troubles like stratification, mud ball formation, sand leakage and also backwashing requirements are reduced highly, thus reducing costs of maintenance as well as saves large quantity of filtered water to be wasted for backwashing.
- The concern filter model improves quality of filtration with respect to parameters such as color, odour, turbidity and hardness.
- Our future scope includes to improve the quality of filtration with respect to bacterial measures.

REFERENCES

[1] Umesh M, "Use of Coconut Shell as Capping for Sand in Rapid Sand Filter", 2017.

[2] Ansari Mubeshshera Awais, "Designing Rapid Sand Filter By Using Coconut Shell for a Village", 2017.

[3] Mota Manoj H, "Improvement of Performance of Rapid Sand Filter using Coconut Shell as Capping Media". International Journal of Science and Research, 2012.

[4] Snehal N Chaudhari, "Modification in Rapid Sand Filter with Coconut Shell as Capping Media", International Journal for Technological Research in Engineering, 2017.

[5] Shilpa S Ratnoji, "A Study of Coconut Shell – Activated carbon for filtration and its comparison with sand filtration", International Journal of Renewable Energy and Environmental Engineering, 2014.

[6] P.M.A Odira, "Performance of Crushed coconut shell Dual media filter", 2007.